Intensity of the Geomagnetic Field During Precambrian Time

Yongjae Yu[1)]* · Seong-Jae Doh[1)]

1. Introduction

Interest in Precambrian paleomagnetic field intensity was sparked by Hale's proposal, on the basis of very limited data, that the Earth's dipole moment had increased markedly around the Archean-Proterozoic boundary (ca. 2.5 Ga), perhaps signaling nucleation/growth of the inner core. Theoretical estimates of the time of inner core formation vary so widely that any firm observational constraint would be extremely valuable. Although there may be additional energy sources, growth of the inner core is believed to be essential for maintaining convection and driving the geodynamo.

2. Method

We first present the data from rapidly cooled rocks, usually with positive baked contact tests demonstrating that the natural remanent magnetization (NRM) is a primarily thermoremanent magnetization (TRM), for which partial TRM (pTRM) checks were carried out, and with 10 or more determinations. Only 6 results are in this A category. If one of the criteria is not fulfilled-the rocks cooled slowly or pTRM checks were not performed or there are < 10 determinations-we classify the results as category B. An additional 10 results are in this category. If two or more of the criteria are not fulfilled, the results are in category C. The 8 results in this category are of doubtful reliability but to exclude them entirely would either depopulate an entire age interval or would conceal a discrepancy between results of similar age from the same area.

3. Results and Discussion

There are only 24 Thellier-type paleointensity estimates for Precambrian rocks. Because orogenesis is episodic, these cluster in a few time intervals: 7 between 820 and 1240 Ma, 7 between 1850 and 2215 Ma, 8 between 2450 and 2765 Ma, and 2 earlier Archean results (3470 Ma). Most late Archean-early Proterozoic results are from dikes. Two results are from large intrusions with multiple phases and slow cooling. Late Precambrian results from the slowly uplifted Grenville Province have an even longer cooling history but pTRMs can be dated fairly accurately by $^{40}Ar/^{39}Ar$ geochronology. The geographic distribution is uneven. Most results are from Canada, Greenland, and Baltica, with only one study each from Africa and Australia. The African and Australian results are thermal overprints rather than primary TRMs. Numbers of acceptable results are often small and standard deviations large. Despite times the published 0.3-300 Ma average, and only two results are conspicuously high (> 10^{23} these limitations, the virtual dipole moments for almost all studies lie within a range of 0.5-1.5 Am^2). There is no

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1) Department of Earth and Environmental Sciences, Korea University (yongjaeyu@naver.com; sjdoh@korea.ac.kr)

obvious record of onset and growth of a dynamo field in the Archean or early Proterozoic. The dipolar nature of the field is debatable. Roughly contemporaneous results confirm the expected dipole dependence of field strength and paleosecular variation on paleolatitude. On the other hand, there is an apparent excess of directional results with low inclinations and paleolatitudes compared to the dipole prediction but this may be due to bias built into the method.